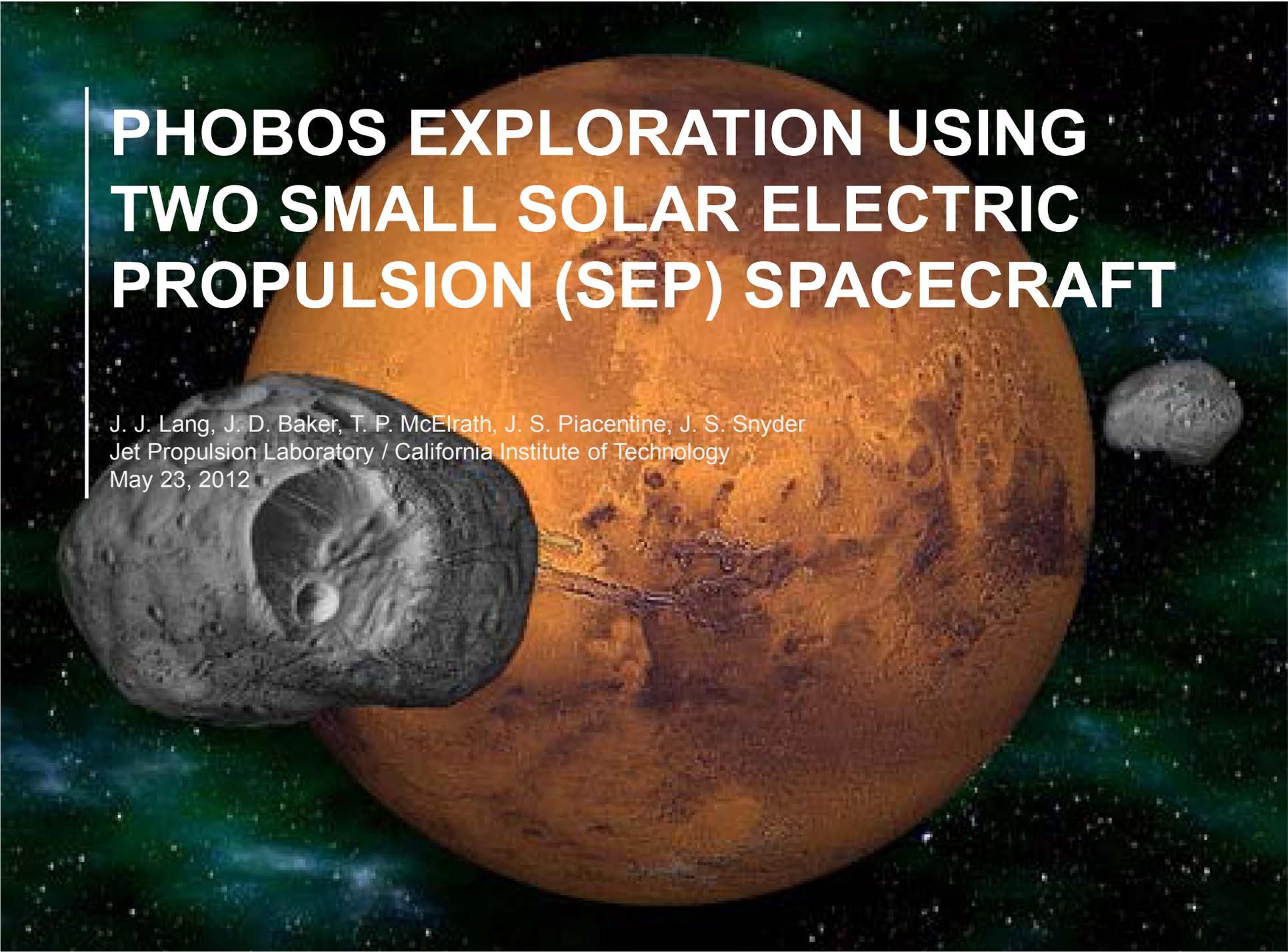


# PHOBOS EXPLORATION USING TWO SMALL SOLAR ELECTRIC PROPULSION (SEP) SPACECRAFT

J. J. Lang, J. D. Baker, T. P. McElrath, J. S. Piacentine, J. S. Snyder  
Jet Propulsion Laboratory / California Institute of Technology  
May 23, 2012



# Why Phobos?

*Phobos and Deimos provide the perfect platform to address both scientific and human objectives for exploration*

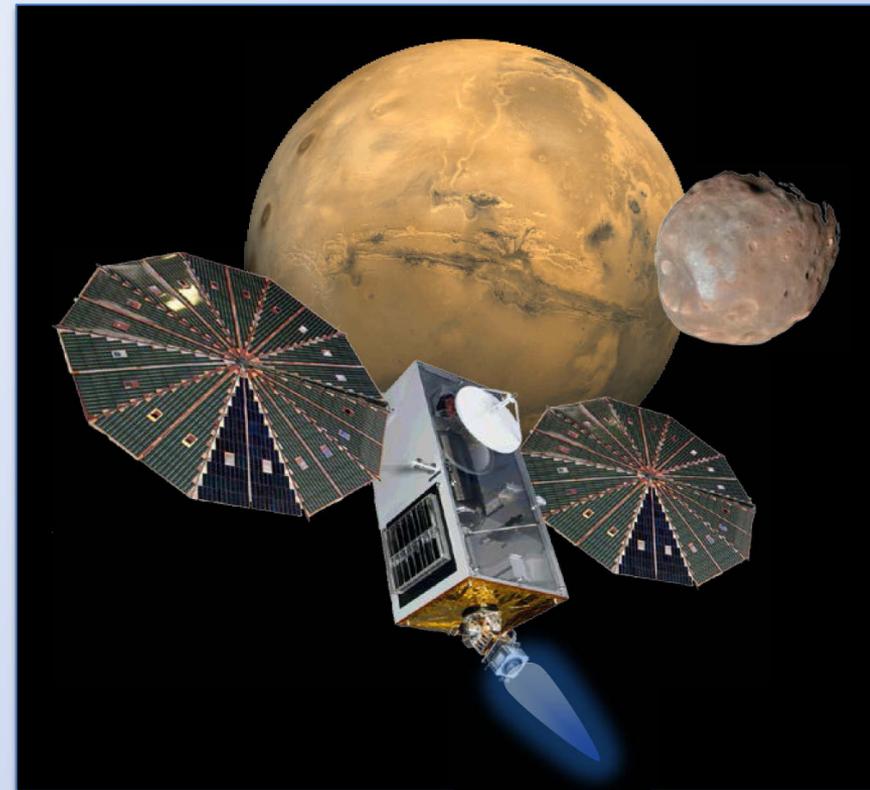
- As a Precursor Mission:
  - Collect critical data in preparation for potential human exploration retiring risk, reducing cost, and optimizing performance
- As a Science Mission:
  - Resolve the origins of the moons, including their relevance as potential targets of astrobiological potential



# Phobos Surveyor: An Innovative Approach

*Phobos Surveyor Mission concept provides an innovative low cost, highly reliable approach to exploring the inner solar system*

- Dual manifest launch
- Use only flight proven, well characterize commercial off-the-shelf components
- Flexible mission architecture allows for a slew of unique measurements



# SEP; Surveyor's Backbone

*Commercially available Solar Electric Propulsion Hall Thrusters enable cost effective, flexible access to Mars*

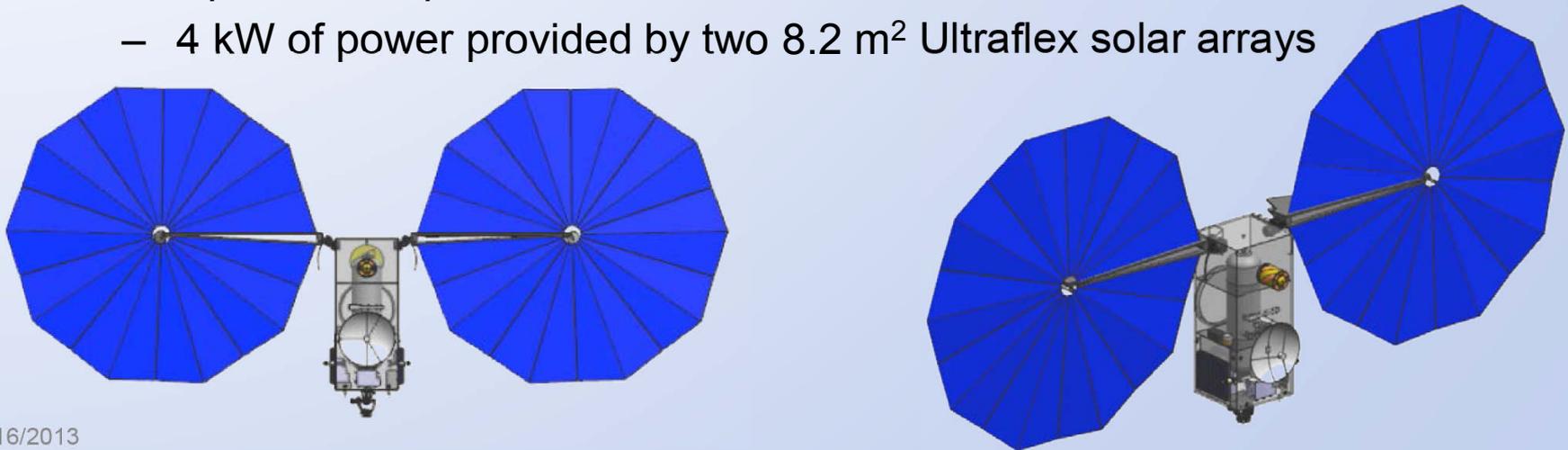
- Hall Thrusters are used extensively and reliably used by Int'l and US Communication Satellites
  - $\approx$  200 satellites using this technology today
  - High heritage systems reduce cost and complexity
  - Current commercial systems are capable of handling interplanetary travel
- Commercial Hall Systems provide the perfect balance between high Isp, high thrust and low power



# The Low Cost, Flexible Spacecraft Design

*The Phobos Surveyor Spacecraft is more than capable of addressing important Human Exploration and Decadal Science Questions*

- Spacecraft Characteristics:
  - Launch mass of ~400 kg/spacecraft (1000 kg total with ESPA Grande launch adapter)
  - 40 kg payload capability
  - Xenon propellant (no hazardous processing required)
  - ~4.5 km/s of delta-V
  - Up to 450 kbps communication via X-band based on Mars distance
  - 4 kW of power provided by two 8.2 m<sup>2</sup> Ultraflex solar arrays

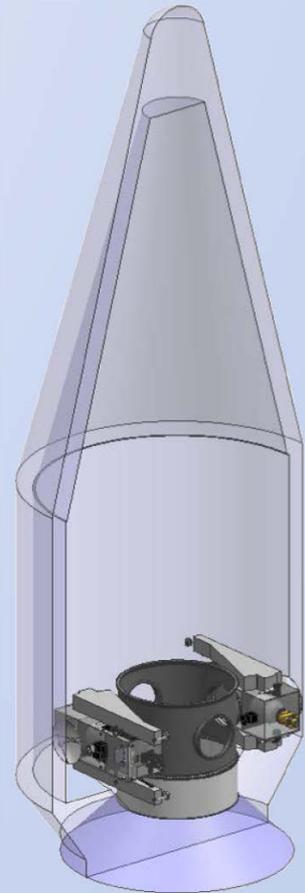




# Increasing Potential Launch Opportunities

*The innovative launch approach of Phobos Surveyor not only lowers cost for planetary missions, but enables more opportunities for focused exploration.*

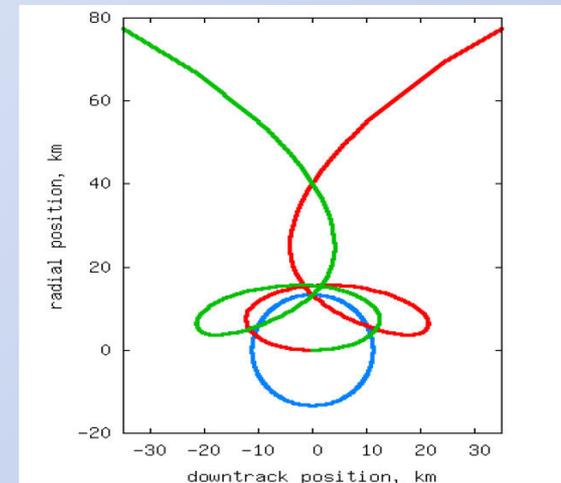
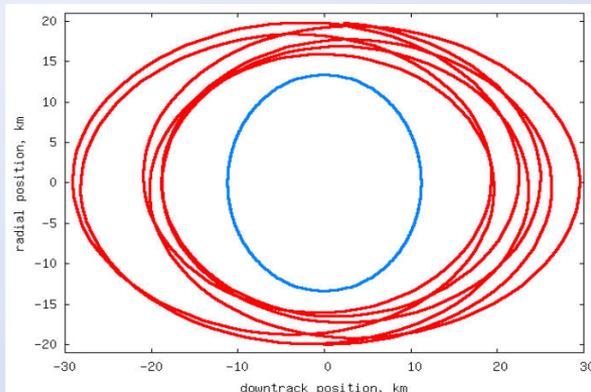
- Phobos Surveyor utilizes three types of launches for rideshare opportunities:
  - Mars direct transfers
  - Lunar / Low energy launches
  - Geosynchronous launches
- Lunar and GEO launches would leverage lunar flybys to depart for Mars



# Flexible Science Operations

*The SEP architecture enable unique operations about Phobos to maximize decadal and precursor scientific return*

- Phobos's shape and gravity enable a variety of potential orbits based on requirements
  - ‘Distant Retrograde Orbit’ provides a stable orbit for imaging
  - ‘Multiple Polar Flyby Orbit’ provides low altitude opportunities to image the poles
  - Several other potential orbits exist

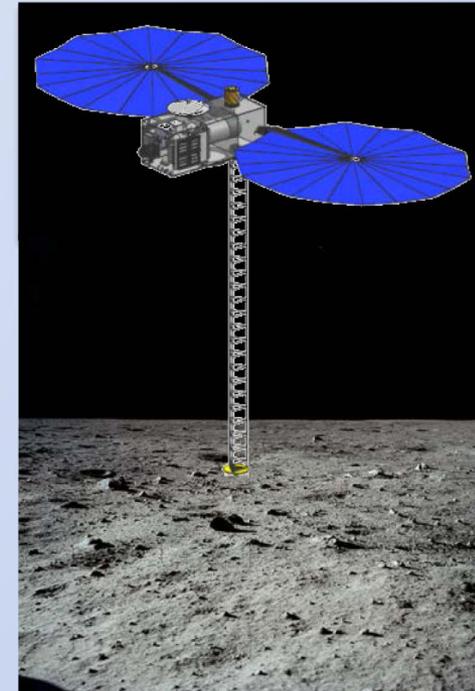




# Potential Landed Exploration

*Phobos Surveyor benefits from Phobos's low gravity to safely access the surface of the body.*

- A 3 m deployable boom allows the orbiter to contact the surface without risking major subsystem components
  - Xenon cold gas system is used to negate the low surface gravity of Phobos
  - Reaction wheels are used to 'balance' the spacecraft atop the boom
  - A small surface package located at the end of the boom conducts surface science
  - Communication is conducted by 'tilting' the spacecraft atop the boom
- Cold gas system could be used to hop to multiple locations





# Conclusion

*Phobos Surveyor offers a unique, innovative and lower cost approach to addressing important Human Exploration and Decadal Science objectives using multiple low cost, highly reliable SEP spacecraft.*



**National Aeronautics and  
Space Administration**  
**Jet Propulsion Laboratory**  
California Institute of Technology

# Questions?